

# ORAL CONTRIBUTIONS

---

## INFO PROJECT & INSTRUMENTATION

- **D. Ferrusca**

### **Astronomical ngVLA sites characterization at Mexican locations**

Initial search of the sites for the ngVLA antennas that will be located in northern Mexico has started, depending on the final configuration of the ngVLA Mid-Array several antennas will be installed in selected sites, different criteria are under consideration for this selection such as existing infrastructure from nearby towns or cities, legal aspects of the lands, terrain physical conditions and vegetation as well as weather conditions. In this talk we present past results of the monitoring of atmospheric parameters of Sierra Negra-Puebla, a millimeter wavelength astronomical site, as well as the infrastructure developed during the past years for this task. Given that experience we propose a new and portable truck to perform the astronomical monitoring and characterization of the selected ngVLA sites with high-level instrumentation, radiometers and real-time data software developed by our group. We also briefly present other instrumentation capabilities available in our laboratories at INAOE and IRyA-UNAM that may benefit the ngVLA instrumentation.

- **D. Hiriart - Instrumentation**

### **Instrumentación para el ngVLA**

Esta plática presenta una descripción general de la instrumentación que se está diseñando para la ngVLA. Se revisan las principales características de diseño en cuanto a su sensibilidad, resolución angular y cobertura de frecuencias para su mejor explotación científica. Asimismo, se presentan los desarrollos instrumentales que se están realizando en México con posibles aplicaciones a la calibración rápida de las fluctuaciones de fase de la atmósfera en las estaciones del ngVLA.

- **A. Trejo**

### **The MID Array, its sites in Mexico, and its capabilities for AGB star studies**

The MID Array of the ngVLA will provide some of the longest baselines of the new observatory. This makes it a critical component for studies requiring some of the finest angular resolutions. MID antennas will be distributed in New Mexico, Texas, and Arizona in the US and in Chihuahua and Sonora in Mexico. We will discuss current work the Mexican community is doing for selecting the final MID sites in Mexico and the associated simulations to characterise the array with its critical longest north-south baselines provided by the antennas in Mexico. Also, we will go into detail about the observatory designs that Mexico is leading: antenna base, antenna site layouts, and antenna supporting buildings.

In the second part of the talk, we will discuss how the ngVLA, and in particular the MID array, could be used for research in AGB stars. Although partially possible with current observatories, the ngVLA will truly enable large surveys of AGB stars to target mass loss and astrometry studies, among others, that are critical to the community.

- **J. Sanchez**

### **Machine learning for interferometric imaging**

Interferometric imaging is an ill-posed problem. Despite the large number of efforts made by the community, there are still several issues faced when images are recovered from sparse arrays

(e.g., VLTI, JWST/SAM, EHT). In this talk, I will present a novel neural network algorithm, called CASSINI-AUTOMAP, to tackle the problem of infrared interferometric image reconstruction. This algorithm looks promising for recovering high-fidelity images by exploiting the new machine-learning developments in neural networks and, the compressibility of astrophysical images in the interferometric domain. While this algorithm has been applied successfully to infrared interferometric data, there are no restrictions to adapt it to the radio domain, where new developments on compressed sensing and regularized minimization algorithms have been tested with important improvements on the image quality.

---

## STAR FORMATION

- **R. Galván**

### **Resolving star formation at all masses with the ngVLA**

TBD

- **G. Ortiz**

Galactic structure and star formation with precision astrometry on the ngVLA

Very Long Baseline Interferometry (VLBI) offers astrometric precision of tens of micro-arcseconds, which is comparable to that offered by the Gaia mission. The six-dimensional information (position and velocity) of young stars obtained with precision VLBI astrometry allows us to investigate the three-dimensional structure of star-forming regions and the internal kinematics of their stellar members. The advantage of VLBI over Gaia is that it can see through the dense material of molecular clouds, reaching the youngest and most embedded stars, thus probing the early stages of star formation. In addition, VLBI astrometry of various types of masers allows the derivation of distances as far as tens of kilo-parsecs, thus proving the structure of the Galaxy at spiral-arm scales. In this talk, I will discuss science cases that will benefit from the improved capabilities of long baselines on the next generation Very Large Array, with a main focus on Galactic structure, young stellar systems and early-stages of stellar evolution and planet formation.

- **C. Román**

### **The VLA Large Survey of Orion A**

The early stages of star and planet formation involve a balance between accretion and ejection of material during the gravitational collapse. This balance and the consequent protostellar evolution are crucial in determining the final properties of stars and their planetary systems.

The VOLS large project will observe the northern region of the Orion A molecular cloud, the nearest star-forming complex containing a broad range of environments populated by protostars and YSOs with different masses and evolutionary stages, representing a testbed for star formation theories. VOLS aims to establish a paradigm in our understanding of the nature of the radio emission from YSOs by building a census of the stellar population down to scales of 120 au. The ultimate goal of the VOLS project is to understand the evolution of the mass-accretion and mass-loss rates across the mass spectrum and birth environment. VOLS will constitute the deepest survey of Orion A at centimeter wavelengths over an area of 0.5 deg<sup>2</sup> (see Figure below for the survey coverage). It will also provide to the community with a legacy database that will be crucial for the next generation of radio interferometers.

- **P. R. Rivera**

### **EARLY MASS-EJECTION IN JET DRIVEN PROTOSTELLAR OUTFLOWS**

Protostellar jets and outflows are an essential agent of star formation feedback, which affects gas physics and chemistry at all scales, from the molecular cloud down to the central parental cocoon. We have used the axisymmetric chemo-hydrodynamical code WALKIMYA-2D to numerically model and reproduce the physical and CO emission properties of the jet-driven outflow from the intermediate-mass protostar Cep E, which was observed at 800 au resolution in the CO J=2→1 line with the IRAM interferometer. Our simulations take into account the observational constraints available on the physical structure of the protostellar envelope to provide constraints on the dynamics of the inner protostellar environment from the study of the outflow/jet propagation away from the launch region. We successfully reproduced the Cep E outflow's main qualitative and quantitative features and jet kinematics, naturally accounting for their time variability. In the early times of the ejection process, the young emitted knots interact with the dense circumstellar envelope through high-velocity, dissociative shocks, which strongly decrease the CO gas abundance in the jet. The distribution of CO abundance along the jet shows that the latter bears memory of the early dissociative phase in the course of its propagation. Analysis of the velocity field indicates that the jet material mainly consists of gas entrained from the circumstellar envelope and accelerated away from the protostar at 700 au scale. As a result, the overall jet mass loss rate appears higher than the actual mass ejection rate by a factor of 3. Numerical modeling of the Cep E jet-driven outflow and comparison with the CO observations have allowed us to peer into the outflow formation mechanism with unprecedented detail and to retrieve the history of the mass-loss events that have shaped the outflow.

• **G. Rangel**

**Cinématica y fotoevaporación de los pilares protoestelares de la región de formación estelar de Carina, caracterizados con ALMA**

Presentamos un estudio de los pilares de polvo y gas que albergan a las fuentes protoestelares generadoras de los objetos Herbig-Haro HH 666, HH 900, HH 1004, HH 1006, HH 1010 y HH 1066 localizados en la región de formación estelar de Carina. Mediante observaciones de alta resolución angular ( $\sim 0.3''$ ) del Atacama Large Millimeter/Sub-millimeter Array (ALMA), detectamos por primera vez las fuentes compactas protoestelares en cada pilar observado a partir del estudio de la emisión del continuo a 1.3 mm y, mediante observaciones de líneas espectrales de C18O (2–1), N<sub>2</sub>D<sup>+</sup> (3–2) y 12CO (2–1), estudiamos la cinématica del gas. Estas nuevas observaciones muestran a los flujos moleculares que emanan de las fuentes compactas, sus envolventes+discos y los objetos HH extendidos alejándose de los pilares. Estimamos que las masas de los discos+envolventes están en un rango de 0.02 a 0.38 M<sub>⊙</sub>, y que las masas de los flujos moleculares son del orden de 10 – 3 M<sub>⊙</sub>, lo que sugiere que sus fuentes podrían ser protoestrellas de masa baja o intermedia, en acuerdo con estudios recientes en bandas infrarrojas y submilimétricas. Además, a partir de la cinématica del gas calculamos las tasas de fotoevaporación de masa para algunas fuentes de nuestra muestra, indicando que el gas presente en los pilares será fotoevaporado en escalas de tiempo del orden de 150 – 2200 años, lo que podría afectar la formación y evolución de planetas en discos protoplanetarios jóvenes.

• **V. Quintero**

**Morphological analysis of the Herbig Ae/Be R CrA type star with near-infrared interferometry**

The formation and evolution of protoplanetary disks are crucial in the formation process of stars and planets. They are key laboratories for magneto-hydrodynamic, radiative, and astrochemical processes. Understanding the processes at play in these dust- and gas-rich circumstellar disks is one of the main science objectives of several current observing facilities.

We study the dust and morphology of the accretion disk around a Herbig Ae/Be star using data from the GRAVITY instrument of the Very Large Telescope interferometer. GRAVITY observes in the K band at a wavelength between 2.0 and 2.4  $\mu\text{m}$ , which allows us to observe the inner regions of the disk. It combines 4 telescope beams and is designed to perform both interferometric imaging and astrometry by phase referencing. GRAVITY is able to resolve features between 4 mas and 50 mas.

Knowing the disk properties at different spatial scales and, in particular, in the innermost regions close to or within the dust sublimation front is critical to understanding the conditions for planet formation and migration in proto-stellar disks around young stars. Zooming into these innermost regions requires angular resolution down to a few milliarcseconds (mas) or less, which is only made possible with optical long-baseline interferometry, in particular with the Very Large Telescope Interferometer (VLTI).

---

## STELLAR EVOLUTION

### • J. Toalá

#### **Evolved Stars under the ngVLA's spotlight**

Mass loss is still one of the major difficulties and unknown parameters in stellar evolution. After leaving the main sequence phase, all stars exhibit considerable mass loss events. The ejecta shocks, heats and compresses the circumstellar medium (CSM) forming nebulae around them. The ejecta enriches the surroundings, setting the stage for the subsequent generation of stars. Although the details might vary depending on the initial mass and on the binarity status of the evolved star, the nebulae can be used as tracers of stellar evolution. Characterising the gas and dust in nebulae around evolved stars is primordial to shed light into the details of mass loss events and, consequently, it helps us peek into the details of stellar evolution. In this talk I will summarise what the ngVLA will be able to do for us to advance in the understanding of nebulae around solar-like stars (planetary nebulae, nova, symbiotic stars) and massive stars (Wolf-Rayet nebulae and LBV stars).

### • L. Sabin

#### **Unveiling the Close Magnetic Environment of Evolved Stars**

The research on magnetic fields in evolved stars, whether they come from low or high mass precursors, remains a relatively unexplored area. High mass-loss in most evolved objects such as (pre)Planetary nebulae, Symbiotic Stars (Symb), Wolf-Rayet (WR), and Supernovae Remnants (SNRs) produces significant amounts of dust and gas. Therefore dust polarization measurements can help trace and study the magnetic fields of these evolved stars, providing detailed information about their strength, structure, and also about the dust characteristics. Such observational studies can help us understanding the interaction between magnetic fields and stellar wind, jet/outflow launching, but also the magnetic fields' impact on stellar evolution as well as the their effects on the shape and distribution of expelled material. These questions still remain unanswered from an observational point of view. We therefore expect to take advantage of the high sensitivity and high resolution of the future ngVLA in polarization mode, which will allow us to have an unprecedented view of the magnetized environment of evolved stars as close as possible from the stellar engine. The possibility of synergies with other complementary facilities is also an interesting aspect to have a full picture of all these astronomical objects.

### • G. Ramos

#### **Hallazgo de Hidrógeno Molecular en la Nebulosa Planetaria M97**

Imágenes profundas en el óptico e infrarrojo obtenidas de los telescopios GEMINI, NOT y CFHT han revelado la presencia de pequeñas aglomeraciones de hidrógeno molecular en la nebulosa planetaria NGC 3587 ó M97, la nebulosa del búho. Este material también se observa en imágenes de Spitzer. La presencia discreta de este material en una nebulosa evolucionada es indicativo de la supervivencia de condensaciones, ya sea debido a su alta densidad inicial o al apantallamiento por polvo.

- **S. Srinivasan**

- **Nearby evolved stars with the (ng)VLA**

Asymptotic giant branch (AGB) and red supergiant (RSG) stars release nucleosynthetic material in the form of gas and dust into the interstellar medium (ISM) through stellar winds, impacting the chemical evolution of galaxies. The dense circumstellar shells around these stars produce abundant dust, which they recycle into the ISM to influence future star formation. AGB and RSG stars are easily identified in infrared observations, while a range of optical to radio measurements is needed to study the material they contribute to the ISM. While large populations of evolved stars have been studied in nearby galaxies, investigating our own neighborhood has been challenging due to foreground extinction in the Milky Way disk, complicating distance estimation.

The Nearby Evolved Stars Survey (NESS; <https://evolvedstars.space>; Scicluna et al. 2022) is a volume-complete sample of ~850 Galactic evolved stars within 3 kpc. NESS employs sub-mm and radio observations of rotational lines (12CO and 13CO J = (1-0), (2-1), and (3-2)) as well as continuum data. Instruments like the JCMT, APEX, ALMA, the Nobeyama Radio Observatory, and the LMT contribute to this survey, combining their observations with existing data to provide a comprehensive understanding of nearby evolved stars.

Due to phenomena such as pulsation and convection associated with evolved stars, Gaia parallaxes for these objects are relatively imprecise. Future Gaia releases may improve the precision, but variability-induced motion and dust scattering pose significant challenges, especially for the dustiest AGB stars that are of particular interest. Although Gaia-NIR could partially address this issue, its launch is not expected for another two decades. In the meantime, ground-based radio interferometry, particularly maser measurements, offers the best alternative for parallax estimation with well-calibrated astrometric accuracy. Only a handful of such maser observations exist for AGB stars within 3 kpc. The existing VLA and VLBA architecture could facilitate such a study and enhance astrometry for the nearest stars in the NESS sample.

In this talk, I will present the survey design for and preliminary findings from NESS, along with proposed synergies between NESS and the VLA/VLBA and the ngVLA.

---

## ASTROCHEMISTRY

- **A. Palau**

- **Astrochemistry with the ngVLA: a new way to trace complex organic molecules and to search for the origin of life**

Las moléculas orgánicas complejas (COMs) son extremadamente importantes en astrobiología porque podrían ser precursoras de las moléculas pre-bióticas. Recientemente, se están encontrando COMs asociadas a discos protoplanetarios, lo que sugiere que los planetas podrían formarse de un material muy rico químicamente y potencialmente apto para desarrollar alguna forma de vida. Aunque esta hipótesis es muy interesante, existen todavía muchas

preguntas acerca de la formación y emisión de las COMs. En concreto, todavía no se comprende su baja tasa de detección. Una posible explicación es la baja sensibilidad de los interferómetros actuales. En esta charla mostraremos la capacidad del ngVLA para detectar estas COMs, tanto en objetos de muy baja masa o proto-enanas marrón como en objetos protoestelares masivos. Además, mostraremos cómo el ngVLA ayudará a resolver la morfología de la emisión de estas COMs, permitiendo determinar su origen asociado a discos protoplanetarios, envolturas en caída, o choques del material eyectado con el medio interestelar. Todo ello resultará crucial para poder determinar de forma fiable la tasa de detección de COMs en los precursores de los discos protoplanetarios de objetos con un amplio rango de masas.

- **Y. Gómez**

### **Visión de los exoplanetas con el ngVLA**

En esta charla presentaré algunas preguntas abiertas en el campo de exoplanetas que pudieran abordarse con las nuevas capacidades que se alcanzarán con el ngVLA.

---

## PLANETARY SYSTEM

- **C. Carrasco**

### **Unveiling the formation of the next generation of planets**

In less than a single decade of high resolution images of ALMA, we have made important steps forward in our knowledge on how protoplanetary disks evolve to give rise to new planetary systems. It is only very recently that we have learned that the dust in the disks tend to segregate to form concentric rings and gaps. These substructures are closely related to the formation of protoplanets. We are also starting to understand that high density rings are most probably the places where dust grows to form planetesimals. However, because of the high densities in these structures, their emission is optically thick at millimeter wavelengths shorter than 3 mm. This makes extremely difficult with ALMA to obtain physical parameters of the dust in the places where they can more easily grow to form planetesimals. Our results also suggest that most of the formation of terrestrial planets is taking place with the most internal parts of the disks, at radii  $<10$  au, where emission is even optically thicker, and we need to detect dust emission at an unprecedented angular resolution. In recent years we have also learned that polarization is a fundamental tool to understand dust properties in protoplanetary disks. However, the low polarization fraction in dust emission requires of much higher sensitivities in order to be detected. All these requirements will be fulfilled by the ngVLA which will be a fundamental instrument to understand how planets are formed.

- **S. Curiel - Planetary system**

### **Búsqueda de exoplanetas usando observaciones de radio**

Hasta ahora se han encontrado más de 5000 exoplanetas, que ya fueron confirmados, y más de 2000 candidatos están a la espera de ser confirmados. La mayoría de estos exoplanetas fueron encontrados usando observaciones ópticas e infrarrojas, principalmente usando las técnicas de velocidad radial y de tránsito. Otras técnicas, como imagen directa, también han dado buenos resultados, pero en menor medida. Astrometría fue la primera técnica en ser usada en la búsqueda de exoplanetas, pero hasta hace poco tiempo no había dado buenos resultados. Se espera que el satélite GAIA cambie esto, con la posible detección de varios miles de exoplanetas usando esta técnica.

También es posible buscar exoplanetas con observaciones en longitudes de onda de radio. Sin embargo, hasta ahora solo se han encontrado unos cuantos candidatos, y la mayoría de ellos tienen masas consistentes con ser enanas café. Recientemente se empezaron a desarrollar nuevas maneras de buscar Exoplanetas usando observaciones de radio. En particular se busca la detección directa de Exoplanetas usando imágenes de radio. También se ha implementado la técnica de astrometría con observaciones en radio. Esta técnica es muy prometedora y ya está dando buenos resultados. Se espera que los radio interferómetros SKA y ngVLA tengan la capacidad de detectar muchos exoplanetas en forma directa e indirecta. Además, las características y la precisión esperadas del ngVLA serán ideales para buscar exoplanetas de alta y baja masa, incluyendo, posiblemente, planetas tipo tierra.

- **A. Arenas**

### **Implementación de código en python para la búsqueda radio astrométrica de compañeras sub-estelares.**

El objetivo de este trabajo fue la búsqueda de compañeras sub-estelares en estrellas jóvenes tipo T Tauri o estrellas de baja masa, usando datos obtenidos con el VLBA y que fueron publicados en varios artículos.

Se estudiaron 8 estrellas, de las cuales en 3 de ellas (DROXO 71, VLA 1\*, LRL 11) se encontró evidencia de posibles compañeras.

Para el objetivo de este trabajo se desarrolló una herramienta para la búsqueda de compañeras sub-estelares. En los ajustes astrométricos realizados se utilizaron el método de mínimos cuadrados no lineales y el método MCMC. El método de mínimos cuadrados no lineales ayuda a encontrar el conjunto de parámetros que minimizan a  $\chi^2$ . Por otro lado, MCMC explora el espacio de parámetros para determinar la distribución de probabilidad posterior de cada parámetro.

Mediante la utilización de observaciones astrométricas altamente precisas que serán obtenidas con el ngVLA, será posible detectar compañeras sub-estelares asociadas a estrellas tipo T Tauri. Además, con la sensibilidad y precisión astrométrica que se espera lograr con el ngVLA, se podrán descubrir planetas asociados a estrellas tipo T Tauri.

- **F. Tapia**

### **In Search of Temperature Minimum at Radio Wavelengths**

In this work, we present a new methodology to fit the observed and synthetic spectrum of solar-like stars at millimeter, submillimeter, and infrared wavelengths through semiempirical models of main-sequence stars chromospheres. We use the Levenberg-Marquardt algorithm as a Nonlinear method, PakalMPI as the semiempirical model of the solar chromosphere, and recent observations of solar-like stars at millimeter, submillimeter, and infrared wavelengths. Our results show that we can use solar chromospheric semiempirical models as an input model to reproduce the observed spectrum of solar-like stars. The new profiles show similarities to the solar chromosphere as a minimum of temperature (without the restriction from CO emission) and a plateau in the high chromosphere. Our method provides a new fast numerical tool to estimate the physical conditions of solar-like stars.

---

## **SIMULATION**

- **A. Cruz Osorio**

### **Using ngVLA to probe gravity, plasma properties and particle acceleration**



To understand and accurately describe the properties of spacetime and plasma in scenarios involving supermassive and stellar black holes, high-resolution multifrequency observations of relativistic jets are necessary. During this presentation, we will cover the state-of-the-art general relativistic magnetohydrodynamics for modeling accretion onto black holes, specifically in scenarios such as M87 and SgrA\*. Additionally, we will discuss the simultaneous measurement of gravitational waves and electromagnetic counterpart through full general-relativity simulation of a stellar system. Lastly, we will explore the potential benefits of using ngVLA to improve image resolution and better constrain our theoretical and numerical models of gravity and plasma physics

- **F. Masset**

### **Thermal forces and their impact on the formation of low-mass planet**

Radiative thermal diffusion in protoplanetary discs leads to significant deviations from the classical picture of resonant interaction between protoplanets and the disc at Lindblad and corotation resonances. The migration rate, eccentricity, and inclination damping rates are notably larger, nearly by an order of magnitude, compared to those estimated for non-luminous planets based on resonant forces. Conversely, planets that are heated by accretion, and reach a sufficient level of luminosity, undergo a growth of eccentricity and inclination, and their migration is reversed. In this presentation, I will discuss some crucial implications of these effects on the formation of low-mass planets, and will briefly discuss their observability with the ngVLA.

- **D.A. Tapia Alanis**

### **Estudio de la robustez del mecanismo de acreción ahogada ante cambios a las condiciones de frontera**

Partiendo de la acreción de Bondi de un fluido politrópico hacia un potencial gravitacional central, se han realizado simulaciones en las cuales se rompe la simetría esférica al imponer un gradiente de densidad entre el ecuador y las regiones polares. A partir de estas simulaciones se han encontrado soluciones estacionarias en las que está presente un mecanismo que redirige parte del flujo entrante y lo expulsa hacia las regiones polares. Además, se ha observado que esta eyección ocurre como consecuencia de la existencia de una tasa de acreción máxima muy cercana a la tasa de acreción de Bondi. Por tener su origen en este exceso de flujo que se embotella cerca del objeto acretor, a este mecanismo se le ha llamado "acreción ahogada".

Mi trabajo consistió en realizar varias simulaciones con el código hidrodinámico aztekas para después analizar cualitativamente la dependencia del mecanismo de acreción ahogada respecto a la parametrización del gradiente de densidad en la frontera externa. Consideré al gas como un fluido politrópico con  $\gamma = 4/3$ . Consideré variaciones de dos perfiles de densidad diferentes en la frontera externa. Para el primero de estos, sumé la contribución de una variable aleatoria con amplitud pequeña, introduciendo ruido al perfil de densidad. Para el segundo de estos perfiles utilicé una función definida a trozos, de modo que en los polos y en el ecuador se tengan funciones constantes y la transición de una a otra esté dada por una función sigmoide. A ésta la defino con dos parámetros con los cuales puedo modificar su posición y su anchura.

En mis simulaciones pude observar que aunque el mecanismo de acreción ahogada sigue apareciendo en las simulaciones que tienen un perfil de densidad con ruido, en el caso de las simulaciones en las cuales el gradiente de densidad lo implementé mediante una función sigmoide encuentro que se presenta un modo cuadrupolar con eyección tanto en las regiones



polares como en el ecuador, lo que limita la aplicabilidad del modelo a perfiles de densidad con gradientes muy abruptos o que se encuentren muy cerca de los polos.

---

## COSMOLOGY

### • O. López-Cruz

#### **SCI-HI: Searching for the first stars at the end of the Dark Ages.**

We are conducting a single antenna experiment to search for variations in the global signal due to the Hydrogen 21 cm line around  $z=20$ . For this aim we have designed and patented a wide-band dipole antenna whose pattern is almost invariant within the 20–110 MHz range. We have designed and constructed detectors for this aim, as well. As part of the project, we have also searched for the best radio-quiet zones in Mexico. We found that Isla Guadalupe (9.0525° N, 118.2761° W) in the Mexican Northern Pacific is one the best radio quiet places in North America.

Here we present recent developments of the experiment Sonda Cosmológica de las islas para la detección de Hidrógeno neutro (SCI-HI). SCI-HI is an international collaboration.

---

## HIGH z GAL and GAL EVOLUTION)

### • I. Aretxaga

#### **Deep surveys of the extragalactic sky**

The ngVLA will operate from 1.2 – 116 GHz (25 – 0.26 cm), accessing the 3mm atmospheric window, which opens a complementary exploratory space to ToITEC at the LMT (1.1/1.4/2.0mm) to identify and study in detail high-z galaxies in deep extragalactic surveys. We will describe the complementarity of continuum observations with these two facilities, and the follow up opportunities of dusty star forming galaxies with ngVLA.

### • V. Avila

#### **Tracing the neutral gas distribution in galaxy surveys: the missing information to understand the full metabolism of galaxies**

I will discuss disk galaxy evolutionary models of self-regulated star formation linking the distributions and kinematics of neutral hydrogen (HI and H<sub>2</sub>) with those of stars, star formation, and its feedback. To constraint these models, we have some information from surveys at  $z\sim 0$  with detailed photometric and spatially-resolved spectroscopic information, such as MaNGA/SDSS-IV and CALIFA, which allow us to infer relevant properties and kinematics of stellar populations and ionized gas. However, information on the spatially-resolved neutral gas distribution and its kinematics is lacking for most galaxies in these surveys. A proposal of great interest would then be to map with ngVLA the galaxies from local IFU surveys ( $z<0.15$ ) at sub-kpc resolution to obtain detailed HI intensity and velocity maps. In this way, we will be able to (1) constrain the local/global baryonic cycle of disk galaxies, which involves cooling and accretion of neutral gas, star formation, photoionization, outflows, etc.; (2) determine some little-studied ingredients of self-regulation models, such as HI velocity dispersion (turbulence); and (3) determine the distribution of angular momentum of the different galaxy components, as well as its kinematics to study the cuspy/core dark matter problem. In addition, by extending the HI mapping to large radii and going down to very low column densities, we will be able to study the

Circumgalactic Medium (associated with dark matter halos and the cosmic web); to determine the amount of gas that is infalling/outflowing into/from galaxies; and to solve some problems such as outer disk truncation and warps.

- **E. Jiménez**

**The VLA 10GHz Survey of GOODS-N: Paving the Way for High-resolution Extragalactic Radio Surveys with the ngVLA**

Structural analyses of high-redshift galaxies are key to understanding the physical processes that drive galaxy evolution across cosmic time. While high-resolution observations from the HST and JWST open a window into dust-unobscured star formation and stellar mass content of high-redshift galaxies, radio continuum imaging at sub-arcsec resolution is needed to trace dust-obscured star formation that dominates the star formation rate density of the Universe out to  $z \sim 5$ . To address this open issue, we have conducted the first high-resolution (0.2 arcsec), high-frequency observational campaign to fully map an extragalactic deep field at unprecedented sensitivity: “The VLA 10GHz Survey of GOODS-N”. Surveying the extragalactic sky at 10GHz has the advantage of yielding higher angular resolution imaging while probing thermal (free-free) radiation of high-redshift galaxies, which is more directly proportional to the rate of massive star formation. The deep 10GHz images of GOODS-N, thereby, provide an extinction-free view for the morphologies of massive star-forming galaxies out to  $z \sim 3$  on 1.7kpc scales. In this talk, I will review the key science goals of the “VLA 10GHz Survey of GOODS-N” and present the data products. I will mention the computational and imaging challenges for this VLA 10GHz survey that foresee the data processing requirements of future ngVLA high-resolution extragalactic radio surveys. Finally, I will discuss how the “VLA 10GHz Survey of GOODS-N” will serve as a pathfinder for future ngVLA observations to trace the sub-kpc scale distribution of star formation of high-redshift galaxies.

- **I. Vega**

**Study of neutral Hydrogen in interacting galaxies**

It is well known that the interaction of two galaxies cause perturbations in the gas inside. This could produce a star formation burst. Another interesting phenomenon is the existence of tidal tails. These are formed from gas ejected from the main galaxies due to the interaction masses of gas. In those tails there are dense clumps of neutral gas (HI), which could evolve into dwarf galaxies. We study the HI in three systems of galaxies at different stages in interaction. In particular we study the density and velocity in tidal tails to see if the clumps present therein are only projection effects or is relaxing and collapsing, forming an independent system like a tidal dwarf galaxy. In addition, the star formation density was determined and we analyzed in a Kennicutt–Schmidt diagram the efficiency of star formation, measure with de HI line, of the external regions of the galaxies in intersection, focusing on the tidal tails. This was possible thanks to the high spatial resolution that we obtained with the VLA data. With this, it is possible to study the star formation in highly turbulent regions, which conditions are similar but not exactly the same to the star formation of the early universe.

---

## AGN

### • A. L. Longinotti

#### **AGN feedback and the role of multi-scale and multi-wavelength outflows**

The well-established relations observed between the properties of host galaxies and their nuclear black hole activity suggest the presence of a solid yet still mysterious mechanism that makes the black hole behavior at nuclear scale impacting the galaxy-scale environment.

In recent years, multi-band observations of AGN-driven outflows have supported the idea that energy-conserving outflows may induce AGN feedback not only in powerful active galaxies, but also at the lower luminosity regime of Seyfert Galaxies.

In this context, tracing each phase of the outflow from the X-ray accretion disc winds to the large scale optical and molecular massive outflow may offer a tool to understand how the initial energy of the nuclear wind is transferred outward. Radio outflows and, in general, AGN radio activity are a key feature of this scenario, holding a yet unexplored potential of tracing shock processes of the outflowing gas with the host galaxy Interstellar Medium.

This talk will present and discuss recent results of feedback in Seyfert Galaxies with multi-wavelength outflows and will offer some perspectives for ngVLA studies and radio observations.

### • A. Pasetto

#### **Polarization of AGN jets in the era of ngVLA**

Radio polarization observations are important to understand the nature of the magneto-ionic medium, internal or external, to the source of study. Through this kind of analysis it is possible: 1) to understand the complexity of the magnetized medium and its possible correlation with the nature of the radio source of study and also 2) to map the magnetic field configuration of AGN jets, to understand how far from the central engine it maintains such configuration and how magnetic fields evolve during the journey along the jets. My presentation will focus on recent full polarization, broadband VLA observations of a nearby AGN jet (M87) and also on broadband VLA polarization analysis of the biggest sample of the Compact Symmetric Objects (CSOs). The above mentioned projects, allow: 1) the study of the polarization emission of the nearby M87 up to kpc scales and, thanks to the good trasversal resolution, the detection of gradients of both the polarization degree and the Faraday depth with the subsequent confirmation of the presence of a helical magnetic field up to 1 kpc; 2) to characterize, for the first time, the broadband continuum and polarized spectrum of the largest CSOs sample, which will give us first indications about the true nature of this class of objects, whether they are in a young evolutionary phase or embedded in a dense ambient medium. The upcoming ngVLA and SKA will easily detect, with high sensitivity and angular resolution, the polarization information of AGN jets in their wide frequency ranges. This will allows us to collect information from the MHz to the GHz window. This will be extremely useful to identify and map the different layers of the magneto-ionic medium which the radiation is embedded in order to understand how the Faraday screens interact with each other and how they evolve. Ultimately, this is important to understand how the polarized medium influence the launching, collimation and evolution of AGN jets.

---

## SINERGY

- **D. Hughes (with Arturo Gómez Ruiz -CONAHCYT / INAOE , Lucas Hunt -NRAO)**  
**The ngVLA and LMT on Sierra Negra**

The Large Millimeter Telescope (LMT) is the world's largest single-dish radio telescope, with a primary reflector diameter of 50-meters, that is designed, constructed and optimized to make observations at wavelengths of  $\sim 1$ mm. The LMT is situated in the state of Puebla in central Mexico (lat. 18.986 degs., long. -97.315 degs.) on the summit of volcán Sierra Negra at an altitude of 4600 meters.

Given the high atmospheric transparency at frequencies  $> 70$  GHz and the geographical location of Sierra Negra (approximately 2000 km SSE of the current VLA site and ngVLA Core sub-array), the LMT site and alternative nearby locations on Sierra Negra offer opportunities for one or more ngVLA antennas to provide unique and extended north-south baselines to the operation of the ngVLA LONG sub-array, and possibly other ngVLA baseline configurations, particularly at the highest frequencies.

Building on previous work, we explore scenarios that demonstrate the contribution in U-V coverage, resolution and sensitivity that additional ngVLA antennas situated on Sierra Negra could make to the various existing ngVLA sub-array configurations over the full operating frequency range (1.2 - 116 GHz). Furthermore, given the demonstrated capability for the LMT to participate in VLBI campaigns with the GMVA, HSA and EHT arrays in the 3mm and 1mm bands respectively, we also consider the possibilities and advantages for the LMT to occasionally join the VLBI observing program of the ngVLA sub-arrays as a stand-alone antenna or in coordination with one or more dedicated ngVLA antennas installed on Sierra Negra.

- **L. Loinard**

### **Sinergías del ngVLA con otros grandes proyectos en Mexico y el mundo**

La construcción y el inicio de operación del ngVLA entre 2025 y 2035 coinciden con la puesta en marcha de numerosos otros proyectos astronómicos internacionales de gran envergadura, tanto en la parte radio (ngEHT, SKA) como en otras regiones del espectro electromagnético (JWST, Vera C Rubin Observatory, Nancy Grace Roman Space Telescope, TMT, GMT, etc.) En esta plática, describiré las potenciales sinergías entre el ngVLA y dichos otros observatorios. Mexico esta en una situación privilegiada para aprovechar muchas de estas oportunidades desde el punto de vista científico y tecnológico. Por ejemplo, la presencia anticipada de antenas del ngVLA y del ngEHT en el norte de Mexico sugiere formas de optimizar combinar y compartir recursos humanos y materiales entre los dos proyectos.

# POSTERS

---

## INSTRUMENTATION

• **J. D. Rojas**

### **Dual K-band Radiometer for Path Delay Measurement - Poster**

We designed a K-band radiometer capable of measuring the electromagnetic path delay caused by atmospheric water vapor content. Our radiometer observes the atmospheric emission at 20 GHz and 25.5 GHz to quantify this delay. In this poster, we present the radiometer design and the data reduction algorithm.

• **I. F. Marquez**

### **Un radio interferómetro para medir retardos de fase de señales electromagnéticas que se propagan en la atmósfera.**

Se diseñó un radio interferómetro de tres elementos en la banda Ku para medir el retardo de fase de señales electromagnéticas que se propagan en la atmósfera, aplicando el método de cerradura de fase para obtener una mayor precisión en la medida y midiendo los retrasos de fase de un radio faro muy estable a 11.92 GHz de un satélite geoestacionario de telecomunicaciones, para caracterizar la estabilidad de la atmósfera.

• **J. Rojas**

### **Study and development of programming topologies in FPGA for the reduction and analysis of data from heterodyne instruments for radio astronomy**

Topologies of programming implemented in FPGAs are currently being developed with a combination of techniques to properly take advantage of hardware resources and maximize their capabilities. In this document we present a hardware architecture for real-time computation of FPGAs and readout applied to spectrometers in radio astronomy. The proposed architecture has been verified on Xilinx ZYNQ 7000 and Virtex-6 (XC6VSX475T-1FFG1759C), which can run at a frequency up to 6 GHz and 4 GHz respectively with high accuracy. We present two spectrometers developed in FPGA's architectures using polyphase filters and FFT on ROACH-2 and decimator with polyphase filters on Zedboard ZYNQ 7000. The spectrometer works continuously and has a remarkable total bandwidth of 200 MHz on ROACH2 and 23 MHz on ZYNQ 7000, resolved into 4096 channels. The firmware on ZYNQ board offer better resolution of 5.6 kHz than ROACH-2 of 49 kHz. DSP48 is the resource most used on ROACH, due to the firmware includes an FFT stage. We discuss the advantages and drawbacks of each approach.

---

## STELLAR FORMATION

• **J. Jáquez**

### **Resolving the Central Regions of Massive Protostellar Objects in the ngVLA Era: Synthetic Observations of Ionized Gas.**

During the formation of massive stars, the innermost parts can have significant ionization in the form of gravitationally-trapped HII regions, jets, and ionized disks or winds. A complete theoretical scenario for the early evolution of ionization feedback in massive star formation is still in the making, but resolved observations of the continuum and kinematical structure of this type of objects will be very important to guide theory. With the resolution and sensitivity that

the ngVLA will offer, a new window will be opened for the study of massive star formation at scales  $\sim 100$  au.

In this work, we present synthetic ngVLA observations of the free-free continuum and recombination lines from ionized disks and jets around massive protostars. Using the SF3DMODELS python package, we create analytical distributions of these objects that are then passed to the RADMC-3D radiative transfer code. Finally, we create synthetic images under simplifying assumptions, and also with the full ngVLA response using the CASA tools.

With the synthetic images, we will quantify the capabilities of the ngVLA to observe and resolve these massive stars in formation. We also have the goal of helping to define the optimal positions of the ngVLA antennas, with emphasis on those that will be placed in northern Mexico.

---

## STELLAR EVOLUTION

- **K. Hernández**

- **Estudio morfológico multifrecuencia de la nebulosa planetaria Sab 6**

El proyecto presenta un estudio morfológico de la nebulosa planetaria Sab 6 ó G129.6+03.4 (UAI), con el objetivo de mostrar la distribución espacial del material ionizado y polvo en este objeto recientemente descubierto. Se utilizaron observaciones de alta calidad en el rango óptico, infrarrojo medio y cercano, obtenidas con diferentes telescopios para analizar la naturaleza del objeto. Las imágenes ópticas fueron procesadas con el programa IRAF para obtener una combinación adecuada en color. Se corroboró que la morfología de una nebulosa planetaria está influenciada por procesos físicos que ocurren en su interior, así como por algunas interacciones con el medio interestelar (MI).

- **E. Santamaría**

- **QU Vul: An integral field spectroscopy case study of a nova shell**

We present GTC MEGARA high-dispersion integral field spectroscopic observations of the nova remnant QU Vul, which provide a comprehensive 3D view of this nova shell. The tomographic analysis of the H $\alpha$  emission reveals a complex physical structure characterized by an inhomogeneous and clumpy distribution of the material within this shell. The overall structure can be described as a prolate ellipsoid with an axial ratio of  $1.4 \pm 0.2$ , a major axis inclination with the line of sight of  $12^\circ \pm 6^\circ$ , and polar and equatorial expansion velocities  $\approx 560$  km s $^{-1}$  and  $400 \pm 60$  km s $^{-1}$ , respectively. The comparison of the expansion velocity on the plane of the sky with the angular expansion implies a distance of  $1.43 \pm 0.23$  kpc. The ionized mass is found to be  $\approx 2 \times 10^{-4} M_\odot$ , noting that the information on the 3D distribution of material within the nova shell has allowed us to reduce the uncertainty on its filling factor.

---

## SIMULATION

- **D. Espitia**

- **Characterization of the Ultra Deep Field of ToITEC at 1.1, 1.4, and 2.0 mm by numerical simulations.**

The study of submillimeter galaxies (SMGs) population is particularly important due to their contribution to the Cosmic Infrared Background (CIB), which in turn represents approximately 50% of the background radiation emitted by extragalactic objects. These are galaxies with high star formation rate at high redshifts and are obscured by dust. ToITEC, a continuum camera with 7716 detectors operating in the 1.1, 1.4, and 2.0 mm wavelength bands, has been installed in the Gran Telescopio Milimétrico (LTM). Among the scientific surveys planned with



ToI TEC is the Ultra Deep Survey (UDS), which aims to cover an area of 0.8 square degrees at the 1.1mm confusion limit. This work uses the latest version of the cosmological motivated simulation of dusty galaxies by Nava-Moreno et al. which already includes lensing. In order to perform all these simulations both the ToI TEC data analysis software stack, ToI TECA, and the data reduction engine Citlali are used. The observational effects as sweep of the sky, atmosphere removal and detectors responses are included which allows to characterize the catalog for the detected sources. In this work, the results of different simulations will be presented, from which a source catalog is extracted using the PyBDSF software (Python Blob Detector and Source Finder). The output catalog is used to characterize the flux recovery, the boosting, estimations of uncertainty in positions, false detection rates based on signal-to-noise ratio cuts, and the completeness.

As future work, the project will center around the extraction of sources from the ToI TEC's Extended Groth Strip (EGS) field. ToI TEC 1.1/1.4/2.0 mm observations of the EGS as the main sample of study, will enable measure mm-source number-counts and focus on the LIR ( $10^{11}$  to  $10^{12}$   $L_{\odot}$ ) population, with James Webb Space Telescope (JWST) associations, so the position of the sources at 1.1mm will determine the optical/NIR/MIR counterpart in the JWST imaging ( $\sim 1''$  astrometric accuracy). The field also has deep Spitzer, Herschel and VLA data that will complement FIR-radio SED studies. The combination of 450/850  $\mu\text{m}$ /1.1mm/1.4mm/2.0mm/1.4GHz photometry will allow to estimate  $\Delta z \sim 0.3$  FIR photometric redshifts (e.g. Aretxaga et al. 2005)

---

## HIGH z GAL and GAL EVOLUTION

### • M. Quirós

#### **Study of the physical properties of Submillimeter Galaxies in the early Universe.**

Understanding the physical properties of Submillimeter Galaxies and their formation and evolution within the large-scale structure of the Universe is one of the goals of recent galaxy surveys. These galaxies, which have extreme infrared luminosities ( $L_{\text{IR}} > 10^{12} L_{\odot}$ ) and the largest star formation rates ( $\text{SFR} > 100 M_{\odot} \text{yr}^{-1}$ ), are known to largely contribute to the cosmic history of star formation up to  $z=4$ , with their contribution at earlier epochs still to be constrained by observations. However, the details in which such extreme star formation episodes occur are not completely understood, particularly at high redshifts. In this work we study a sample of  $\sim 1800$  potentially high- $z$  red Herschel sources ( $S_{250 \mu\text{m}} < S_{350 \mu\text{m}} < S_{500 \mu\text{m}}$ ) using continuum archival data from the Atacama Large Millimeter/submillimeter Array (ALMA) at 1.3 mm and the *Herschel* Space Observatory in the SPIRE bands. The high angular resolution and sensitivity of the ALMA observations allow us to study the multiplicity, dust properties, star formation, and luminosity of this sample of bright, high-redshift galaxies. This information allows us to constrain the luminosity distribution of the Submillimeter Galaxies and their contribution to the cosmic star formation history. The development of new instruments and facilities, such as the ngVLA, will provide the means to explore in more detail the physical properties of these galaxies, shedding light on their molecular gas content and distribution, and offering new insights on the processes that trigger the extreme star formation episodes of these galaxies.

### • D. Pérez Millán

#### **Galaxy evolution in clusters: a study of Abell 2670 in the HI and in the optical**

##### Abstract

We study the transformations taking place in late-type galaxies due to the effect of ram-pressure in environments of rich galaxy clusters. With this respect, we chose the

massive, rich, X-ray bright and non-relaxed cluster Abell 2670 (A2670). One of the nearest rich clusters well-studied. In this regard, we used NRAO-VLA observations of the 21cm line and detected the galaxies with HI content, analyzing the HI perturbation in deficiency, offset, asymmetry and kinematics. For this, we created channels and HI maps, and velocity fields maps. We also searched for late-type galaxies in databases brighter than  $g < 19.0$ , in order to create a catalog for HI-rich galaxies and HI non-detected. Using the software SExtractor, we also identified the galaxies in A2670 until  $g = 19.0$  in optical images taken by the 3.6m CFHT, for studying the asymmetry degree for the old stellar component. We also made color images to compare their apparent morphology type with the literature. We analyze the 3D distribution throughout the cluster of galaxies, according to their HI content, perturbation and near-IR asymmetry. Finally, we studied the dynamical state with its X-ray emission, to estimate the ram-pressure, and confirming recent research that A2670 presents a current state of merging far from relaxation.

---

## AGN

• J. Luna

### **Multi-wavelength SED modeling of the jetted hybrid AGN sources PKS 2004-447, 3C 286 and PKS0440-00**

The detection of gamma-ray emission coming from Narrow-Line Seyfert 1 Galaxies (NLS1s) and Compact Steep-Spectrum radio sources (CSS) by Fermi/LAT, confirming the presence of relativistic jets, has attracted interest in exploring the connection between these jetted active galactic nuclei (AGN). The existence of sources that share properties associated with two classes, considered hybrids (in this case, NLS1s with blazar-like spectral energy distributions or radio characteristics similar to CSS), has been thought as an indication of the unification between them. In this work, we explore the true nature of three hybrid sources; PKS 2004-447, 3C 286 and PKS0440-00, through the modeling of the multi-wavelength Spectral Energy Distribution (SED), from radio to gamma-rays. We found evidences in the derived physical parameters such as orientation effects on the SED shape, the richness of the photon external fields, and parameters related to jet production and the accretion disk, that allow us to discuss the classification of the sources and possible link between the classes.